IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of
Yutaka Saitou et al.
Serial No. : 10/521,490 **Group Art Unit: 2618**
Filed: January 18, 2005 **Examiner: Mr. Young, Janelle N**

For: Portable wireless machine
Assistant Commissioner for Patents
Alexandria, VA 22313-1450

STATEMENT UNDER 37 C.F.R. 1.55(a)

Sir,

I, Tomonori Nakamura, hereby declare that I am conversant with both English and Japanese languages, and certify to best of my knowledge and belief that the attached are true and correct English translation of Japanese Patent Application No. 2002-210612 filed on July 19, 2002.

T. Nakamura

Tomonori Nakamura

Date: March 6, 2007

PATENT OFFICE

Japanese Government

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: July 19, 2002

Application Number: 2002-210612

Applicant(s): MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.

[Document Name] Patent Application

[Reference No.] 2903240071

[Addressee] Commissioner, Patent Office Esq.

[Intl. Patent Classification] H01Q 1/24

[Inventor]

[Address or Residence] c/o MATSUSHITA COMMUNICATION Kanazawa R&D Lab. Co., Ltd., 1-3, Sainen 1-chome, Kanazawa-shi, Ishikawa, Japan

[Name] Yutaka Saitou

[Inventor]

[Address or Residence] c/o MATSUSHITA COMMUNICATION Kanazawa R&D Lab. Co., Ltd., 1-3, Sainen 1-chome, Kanazawa-shi, Ishikawa, Japan

[Name] Yoshio Koyanagi

[Inventor]

[Address or Residence] c/o MATSUSHITA COMMUNICATION INDUSTRIAL CO., LTD., 3-1, Tsunashimahigashi 4-chome, Kohoku-ku, Yokohama-shi, Kanagawa, Japan

[Name] Kenichi Yamada

[Applicant for Patent]

[Identification No.] 000005821

[Name or Appellation] MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.

[Agent]

[Identification No.] 100105647

[Attorney]

[Name or Appellation] Shohei Oguri

[Telephone No.] 03-5561-3990

[Selected Agent]

[Identification No.] 100105474

[Attorney]

[Name or Appellation] Hironori Honda

[Telephone No.] 03-5561-3990

[Selected Agent]

[Identification No.] 100108589

[Attorney]

[Name or Appellation] Toshimitsu Ichikawa

[Telephone No.] 03-5561-3990

[Selected Agent]

[Identification No.] 100115107

[Attorney]

[Name or Appellation] Takeshi Takamatsu

[Telephone No.] 03-5561-3990

[Selected Agent]

[Identification No.] 100090343

[Attorney]

[Name or Appellation] Yuriko Kuriu

[Telephone No.] 03-5561-3990

[Indication of Fee]

[Deposit Account Number] 092740

[Amount] 21,000 Yen

[List of Filed Documents]

[Filed Document Name] Specification 1

[Filed Document Name] Drawing 1

[Filed Document Name] Abstract 1

[General Power of Attorney No.] 0002926

[Request for Proof] Request

[Designation of Document] SPECIFICATION

[Title of the Invention] PORTABLE RADIO DEVICE

[Claims]

[Claim 1]

A portable radio device comprising:

an upper casing and a lower casing which can be folded about a hinge portion;

an upper antenna element and a lower antenna element respectively built in the upper casing and the lower casing; and

a feeding portion having one end electrically connected to the upper antenna element and the other end electrically connected to the lower antenna element,

wherein the upper antenna element and the lower antenna element serves as a dipole antenna.

[Claim 2]

The portable radio device according to claim 1, wherein the upper antenna element includes a plurality of upper antenna elements and the plurality of upper antenna elements are selectively connected to one end of the feeding portion by switching means.

[Claim 3]

The portable radio device according to claim 2, further comprising the switching means for selectively electrically connecting the plurality of the upper antenna

elements to the feeding portion and the lower antenna element.

[Claim 4]

The portable radio device according to claim 2, further comprising:

first and second upper antenna elements;

a half-wavelength element electrically connected to the second upper antenna element; and

the switching means for selectively electrically connecting one of the first upper antenna element and the half-wavelength element to the feeding portion.

[Claim 5]

The portable radio device according to claim 2, further comprising:

first and second upper antenna elements;

first and second half-wavelength elements electrically connected to the first and second upper antenna elements, respectively; and

the switching means for selectively electrically connecting one of the first and second upper antenna elements and the first and second half-wavelength elements to the feeding portion.

[Claim 6]

The portable radio device according to any one of claims 2 to 5, further comprising a plurality of impedance

matching means corresponding to the plurality of the upper antenna elements, respectively.

[Claim 7]

The portable radio device according to any one of claims 2 to 5, further comprising:

casing opening and closing state detecting means for detecting whether the upper casing and the lower casing are opened with respect to each other; and

control means for controlling the switching means in accordance with the detection result of the casing opening and closing state detecting means.

[Claim 8]

The portable radio device according to any one of claims 2 to 5, further comprising control means for controlling the switching means so as to raise a reception level by determining the reception level of a radio circuit portion.

[Claim 9]

The portable radio device according to any one of claims 1 to 8, wherein the upper antenna element and the lower antenna element are respectively formed in the shape of a plate along the surfaces of the upper casing and the lower casing.

[Claim 10]

The portable radio device according to claim 9, further comprising a radio circuit portion formed on a printed circuit board,

wherein the lower antenna element is formed as a ground pattern which is formed on the printed circuit board provided in the lower casing,

wherein a ground of the radio circuit portion is electrically connected to the ground pattern, and

wherein the feeding portion of the radio circuit portion is electrically connected to the upper antenna element or the switching means.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a portable radio device such as a foldable cellular phone.

[0002]

[Prior Art]

Folder type which is one kind of structures of a cellular phone has a mechanism including an upper casing and a lower casing connected by a hinge so as to freely rotate and be freely open and close. The foldable cellular phone is provided with an enlarged display screen on the upper casing, and has advantages which are a

convenience at the time of using in an opening state and a compact shape in a closing state.

[0003]

In a known foldable cellular phone, as an antenna of a foldable cellular phone, it is available that a protrusion type antenna disposed in the lower casing is disclosed in JP-A-2002-27066 or a protrusion type antenna disposed in the upper casing is disclosed in JP-A-2001-45123. For such a protrusion type antenna, a helical antenna or an extensible mono-pole antenna is ordinarily employed. Since the antenna portion protrudes from the case, an antenna gain can be raised while a hand holds the cellular phone.

[0004]

As compared therewith, as an antenna contained in the case of the foldable cellular phone, a strip line antenna is disclosed in JP-A-10-308618. Further, in JP-A-2001-284934, a hinge portion contained antenna is disclosed.

[0005]

Still further, as a flip type antenna contained in the case of the cellular phone, a coil type antenna is described in JP-A-9-64778 and a micro-strip line antenna is described in JP-A-10-190330.

Further, JP-A-10-84406 discloses a plurality of

element contained antenna in which a dipole antenna as a radiation element contained in an upper casing is combined with a non-feeding element contained in a lower casing.

[0006]

[Problem that the Invention is to solve]

However, the known protrusion type antenna has a problem that a protruding structure of an antenna portion is disturbed while using. The reason is the antenna portion is caught by a part of a pocket or the like when a cellular phone inserted in the pocket is taken out.

[0007]

Alternatively, since the above-described antenna contained in the case has no part protruding from the case, there is not the same problem. However, in the hinge portion contained antenna, under a state in which the cellular phone is allowed to come near to the ear and the mouth to speak (refer this state as to a speaking state, hereinafter), when the hinge portion is held by a hand, there is a problem that the antenna gain may be sometimes undesirably deteriorated, because the antenna portion is covered with the hand.

[0008]

Further, in the flip part contained antenna, there is an advantage that the antenna portion is not covered with the hand in the speaking state. Conversely, while

the flip part is closed, a cellular phone main body is allowed to come near to the antenna portion, so there is a problem that the antenna gain may be possibly deteriorated.

[0009]

Still further, in the plurality of element contained antenna, while the first and lower casings are closed, there is an advantage that a high antenna gain can be secured. Conversely, while the first and lower casings are opened to speak, when a part near the radiation element is covered with a hand, the antenna gain may be undesirably deteriorated.

[0010]

As mentioned above, since the contained antenna has a problem that the gain of the contained antenna in the specific using state is lower than that of the protrusion type antenna, it is not easy to avoid this problem in a single contained antenna. However, for example, when a plurality of contained antennas are disposed on a plurality of locations of the first and lower casings so as to switch over them and a sufficient gain is secured by any one of the contained antenna, it may be possible to obtain a high antenna gain.

[0011]

However, to dispose the known contained antennas on a plurality of locations, a large space is necessary for

building a plurality of antenna in the first and lower casings, and thus securing the space makes a decrease in thickness to disturb.

[0012]

In consideration of the aforementioned situations, it is an object of the present invention to provide a foldable cellular phone including a contained antenna which has a high gain under various using states and being capable of decreasing in thickness.

[0013]

[Means for solving the Problem]

A portable radio device includes an upper casing and a lower casing which can be folded about a hinge portion, an upper antenna element and a lower antenna element respectively built in the upper casing and the lower casing, and a feeding portion having one end electrically connected to the upper antenna element and the other end electrically connected to the lower antenna element, wherein the upper antenna element and the lower antenna element serves as a dipole antenna.

[0014]

Due to this structure, the antenna elements respectively accommodated in the first and second cases integrally operate as the dipole antenna. Thus, under a using state in which the portable radio device is held by

a hand, a high antenna gain can be operationally obtained.

[0015]

Further, in the portable radio device according to the present invention, the upper antenna element includes a plurality of upper antenna elements and the plurality of upper antenna elements are selectively connected to one end of the feeding portion by a switching means.

[0016]

Due to this structure, a directional diversity effect can be obtained. Under a speaking state, even when the portable radio device is held by either of a left hand and a right hand, a high antenna gain can be obtained.

[0017]

additionally, the portable radio device according to the invention further includes the switching means so as to switch whether the plurality of the upper antenna elements are electrically connected to the feeding portion or the plurality of the upper antenna elements are electrically connected to the lower antenna element, respectively.

[0018]

Due to this structure, a diversity effect having a higher directivity is operationally obtained.

[0019]

The portable radio device according to the invention further includes first and second upper antenna elements, a half-wavelength element electrically connected to the second upper antenna element, and the switching means for selectively electrically connecting one of the first upper antenna element and the half-wavelength element to the feeding portion.

[0020]

Due to this structure, even when the portable radio device is closed, a high antenna performance is obtained.

[0021]

The portable radio device according to the invention further includes first and second upper antenna elements, first and second half-wavelength elements electrically connected to the first and second upper antenna elements, respectively, and the switching means for selectively electrically connecting one of the first and second upper antenna elements and the first and second half-wavelength elements to the feeding portion.

[0022]

Due to this structure, even when the portable radio device is closed, a high antenna performance can be obtained and a directional diversity effect can be also obtained.

[0023]

The portable radio device according to the invention further includes a plurality of impedance matching means corresponding to the plurality of the upper antenna elements, respectively.

[0024]

Due to this structure, even when the portable radio device is closed, the high antenna performance can be obtained.

[0025]

The portable radio device according to the invention further includes casing opening and closing state detecting means for detecting whether the upper casing and the lower casing are opened with respect to each other, and control means for controlling the switching means in accordance with the detection result of the casing opening and closing state detecting means.

[0026]

Due to this structure, a high antenna performance corresponding to the opening or the closing state of the portable radio device can be obtained.

[0027]

The portable radio device according to the invention further includes control means for controlling the switching means so as to raise a reception level by determining the reception level of a radio circuit portion.

[0028]

Due to this structure, a high antenna performance can be always ensured under various using states of the portable radio device.

[0029]

In the portable radio device according to the invention, the upper antenna element and the lower antenna element are respectively formed in the shape of a plate along the surfaces of the upper casing and the lower casing.

[0030]

Due to this structure, the upper antenna element and the lower antenna element are respectively incorporated in the upper casing and the lower casing. However, the upper casing and the lower casing can be respectively formed with small thickness, so that they can sufficiently operationally meet a light and thin portable radio device.

[0031]

The portable radio device according to the invention further includes a radio circuit portion formed on a printed circuit board, wherein the lower antenna element is formed as a ground pattern which is formed on the printed circuit board provided in the lower casing, wherein a ground of the radio circuit portion is electrically connected to the ground pattern, and wherein

the feeding portion of the radio circuit portion is electrically connected to the upper antenna element or the switching means.

[0032]

Due to this structure, a high antenna performance can be ensured and a thin portable radio device can be easily formed.

[0033]

[Best Mode for Carrying out the invention]

Hereinafter, embodiments of the invention will be described by referring to drawings.

First Embodiment

Fig. 1 is a schematic structural diagram of a portable radio device in a first embodiment of the invention. The portable radio device in this embodiment is a portable radio device having a foldable structure and is shown in an opened state (refer this state as to an opening state, hereinafter) in Fig. 1. The portable radio device includes an upper case 1, a lower case 2, a hinge portion 3, a plate shaped conductor 4, a plate shaped conductor 5, a ground plate 6, a speaker 7, an operating key 8 and a microphone 9.

[0034]

The upper case 1 and the lower case 2 as one example of an upper casing and a lower casing are formed with a

resin as an insulator and ordinarily set to the length of about 100 mm and the width of about 50 mm. The upper case 1 and the lower case 2 are respectively connected in the hinge portion 3 so as to freely rotate. Thus, a foldable structure is formed.

[0035]

In the upper end part of the upper case 1, the speaker 7 is disposed. In the lower end part of the lower case 2, the microphone 9 is disposed respectively. In a speaking state that a user holds the portable radio device by a hand to speak, the user can use the portable radio device by allowing the speaker 7 to come near to the ear and the microphone 9 to come near to the mouth respectively.

[0036]

The plate shaped conductors 4 and 5 as one example of an upper antenna element are made of a copper plate having, for instance, the length of about 90 mm and the width of about 15 mm. The plate shaped conductors are disposed along the surface of the upper case 1 in the inner part of the upper case 1. Further, the thickness of the plate shaped conductors 4 and 5 is set to, for instance, about 0.1 mm. The plate shaped conductors are disposed so as not to structurally interfere with other components such as the speaker 7 or a display element in

the inner part of the upper case 1 having the thickness as thin as, for instance, about 6 mm.

[0037]

The ground plate 6 as one example of a lower antenna element is made of, for instance, a conductor plate having the length of about 90 mm and the width of about 45 mm. The ground plate may use a ground pattern of a printed circuit board disposed in the lower case 2. The ground plate 6 whose thickness is set to 1 mm or smaller is disposed so as not to structurally interfere with other components such as the operating key 8 or the microphone 9 in the lower case 2.

[0038]

A feeding point 10 and a feeding point 11 provided in the lower parts of the plate shaped conductor 4 and the plate shaped conductor 5 are electrically connected to a high frequency switch 14 by a feeder 12 and a feeder 13. As the feeder 12 and the feeder 13, a flexible wire rod that can be freely bent is used. Thus, the upper case 1 can rotate in the hinge portion 3.

[0039]

The high frequency switch 14 is formed by, for instance, an FET or a PIN diode to suitably select the high frequency signals of the feeder 12 and the feeder 13(suitably select a larger one of the high frequency

signals on the basis of, for instance, the directions of the cases 1 and 2 or the magnitude of the high frequency signals of the feeders 12 and 13) to transmit the high frequency signal to one end of a feeding portion 15. The feeding portion 15 is an antenna feeding portion of a transmitting and receiving circuit disposed in the lower case 2. The other end of the feeding portion 15 is grounded in the ground plate 6.

[0040]

In the portable radio device constructed as described above, an operation of an antenna when radio frequency is set to, for instance, 900 MHz (a wavelength is about 333 mm) is described below as an example.

In the high frequency switch 14, when an A side terminal is selected, the plate shaped conductor 4 is selected. In this case, the plate shaped conductor 4 and the ground plate 6 operate as, for instance, a dipole antenna of half-wavelength. Further, when the high frequency switch 14 selects a B side terminal, the plate shaped conductor 5 and the ground plate 6 likewise operate as, for instance, a dipole antenna of, about half-wavelength. Accordingly, the plate shaped conductors 4 and 5 and the ground plate 6 operate as the dipole antenna provided in the upper case 1 and the lower case 2 of the portable radio device.

[0041]

The antenna current of the dipole antenna constructed as described above is distributed over a wide range from the upper ends of the plate shaped conductors 4 and 5 and the lower end of the ground plate 6. Accordingly, for instance, when the user holds only the lower case 2 by the hand, or when the user holds only the hinge portion 3 by the hand, the deterioration of an antenna gain is suppressed to a minimum. This arises because of a reason why the antenna current is distributed throughout a wide range from the upper end of the upper case 1 to the lower end of the lower case 2. Thus, even when the antenna current of a specific part is influenced by the hand, the influence given to the operation of the entire antenna is low.

[0042]

Fig. 2 is diagrams showing the directivity of the dipole antenna shown in Fig. 1. In Fig. 2, the directivity 16 and the directivity 17 respectively show the directivities of Eθ (vertically polarized wave) components on an XY plane. Further, the directivity 18 and the directivity 19 respectively show the directivities of Eθ components on an YZ plane.

[0043]

Further, the directivity 16 and the directivity 18

show the directivities of a state that the A side of the high frequency switch 14 in Fig. 1 is selected, that is, the plate shaped conductor 4 is selected. Further, the directivity 17 and the directivity 19 show the directivities of a state that the B side of the high frequency switch 14 is selected, that is, the plate shaped conductor 5 is selected.

[0044]

As apparent from Fig. 2, when the plate shaped conductor 4 is selected, a gain in the direction of Y is high. When the plate shaped conductor 5 is selected, the gain in the direction of -Y is high. As described above, when the plate shaped conductor 4 or the plate shaped conductor 5 having a higher gain is automatically selected by the high frequency switch 14, a directional diversity effect can be obtained.

[0045]

Now, the antenna gain under a state that the portable radio device in a speaking state will be described below. Fig. 3 is diagrams showing speaking states that the user holds the portable radio device by a left hand or a right hand to allow the device to come near to the ear or the mouth for speaking. As shown in Fig. 3, under the speaking state, the portably radio device is frequently inclined by about 60 degrees from a direction

of Z. Further, the hand by which the user holds the portable radio device cannot be frequently limited to the left hand or the right hand. Accordingly, under both the states shown in Fig. 3, the high antenna gain is required for the portable radio device.

[0046]

In a land mobile telecommunication system like a portable telephone system, it has been know that a radio wave coming to the portable radio device from a radio base station has an elevation angle θ of 90 degrees in coordinate systems shown in Fig. 3, that is, the radio wave is concentrated in the direction of a horizontal plane (XY plane). Accordingly, the high antenna gain in the direction of the horizontal plane is required for the antenna for the portable radio device under both the states shown in Fig. 3.

[0047]

Fig. 4 respectively show directivities on an XZ plane under a state that the portable radio device shown in Fig. 1 is disposed to be inclined by 60 degrees, that is, when the portable radio device is located in the speaking states shown in Fig. 3. Coordinate systems shown in Fig. 4 respectively correspond to the coordinate systems shown in Fig. 3.

[0048]

In Fig. 4, the directivity 20 and the directivity 21 respectively show the directivities of Eθ (vertically polarized wave) components on the XZ plane when the portable radio device is held by the left hand. Further, the directivity 22 and the directivity 23 respectively show the directivities of Eθ (vertically polarized wave) components on the XZ plane when the portable radio device is held by the right hand.

[0049]

Further, the directivity 20 and the directivity 22 show the directivities of a state that the A side of the high frequency switch 14 in Fig. 1 is selected, that is, the plate shaped conductor 4 is selected. Further, the directivity 21 and the directivity 23 show the directivities of a state that the B side of the high frequency switch 14 is selected, that is, the plate shaped conductor 5 is selected.

[0050]

As apparent from Fig. 4, when the portable radio device is held by the left hand, the directivity 21 of the state that the plate shaped conductor 5 is selected has a higher gain on the XY plane. Further, when the portable radio device is held by the right hand, the directivity 22 of the state that the plate shaped conductor 4 is selected has a higher gain on the XY plane. As described above,

when the right hand and the left hand respectively hold the portable radio device, the different plate shaped conductors 4 and 5 respectively have higher gains. In this embodiment, this phenomenon is employed to provide, for instance, a detecting unit, which is not shown in the drawings, for automatically detecting the directions of the cases 1 and 2, that is, whether the portable radio device is held by the right hand or the left hand. A switching unit is provided for automatically switching the high frequency switch 14 shown in Fig. 1 to the higher gain in accordance with the directions of the cases 1 and 2 detected by the detecting unit. Thus, the high antenna gain can be obtained in any of the speaking states that the portable radio device is held by the left hand or the right hand. Further, a measuring unit for measuring the respective gains of the plate shaped conductors 4 and 5 and a switching unit for automatically switching the switch to the higher gain on the basis of the gains measured by the measuring unit may be provided, so that the high antenna gain can be obtained in any of the speaking states that the portable radio device is held by the left hand or the right hand.

[0051]

In this embodiment, the two plate shaped conductors are incorporated in the upper case 1 to switch them.

However, a single plate shaped conductor may be provided in the upper case. Also in this case, the antenna gain in a speaking state can be improved.

[0052]

The form of the plate shaped conductor contained in the upper case 1 is not limited to the form shown in this embodiment. A structure operating together with the ground plate contained in the lower case 2 as a dipole antenna of, for instance, about half-wavelength may obtain the same effects.

[0053]

The plate shaped conductors contained in the upper case 1 may be respectively formed with a conductor for supporting, for instance, a liquid crystal display in view of a mechanism, or the plate shaped conductor may be respectively formed with a conductor thin film stuck to the surface of a resin of the upper case 1 or a conductor thin film embedded in the resin.

[0054]

Further, in order to reduce an influence that the portable radio device is allowed to come near to the head part of a user, particularly to the ear under a speaking state, the plate shaped conductors incorporated in the upper case 1 are desirably arranged at positions separate from the surface of the upper case 1 on which the speaker

7 is disposed, that is, at positions near a surface opposed to the surface on which the speaker 7 is disposed as much as possible.

[0055]

Second Embodiment

Fig. 5 is a schematic structural diagram of a portable radio device in a second embodiment of the present invention. The portable radio device in this embodiment is also a portable radio device having a foldable or collapsible structure. In Fig. 5, an opened state (refer this state to as an opening state, hereinafter) is shown. In Fig. 5, duplicated portions of Fig. 1 are designated by the same reference numerals of Fig. 1.

[0056]

Comparing to the portable radio device shown in Fig. 1, the portable radio device shown in Fig. 5 further includes the plate shaped conductor 4 or the plate shaped conductor 5 that is not selected is grounded in a ground plate 6.

In Fig. 5, feeders 12 and 13 are respectively connected to high frequency switches 24 and 25. The high frequency switch 24 performs an operation for switching whether an electric signal of the feeder 12 is transmitted to a feeding portion 15 or grounded to the ground plate 6.

Further, the high frequency switch 25 performs an operation for switching whether an electric signal of the feeder 13 is transmitted to the feeding portion 15 or grounded in the ground plate 6.

[0057]

Here, for instance, when a terminal B1 side of the high frequency switch 25 is selected and the plate shaped conductor 5 is connected to the feeding portion 15, a terminal A2 side of the high frequency switch 24 is selected and the plate shaped conductor 4 is grounded in the ground plate 6. On the contrary, when a terminal A1 side of the high frequency switch 24 is selected and the plate shaped conductor 4 is connected to the feeding portion 15, a terminal B2 side of the high frequency switch 25 is selected and the plate shaped conductor 5 is grounded in the ground plate 6.

[0058]

Fig. 6 show directivities when the high frequency switches are operated as described above. In Fig. 6, the directivity 26 and the directivity 27 respectively show the directivities of $E\theta$ (vertically polarized wave) components on an XY plane. In Fig. 6, the directivity 28 and the directivity 29 respectively show the directivities of $E\theta$ components on an YZ plane.

[0059]

Further, the directivity 26 and the directivity 28 show the directivities of a state that the terminal A1 side of the high frequency switch 24 and the terminal B2 side of the high frequency switch 25 in Fig. 5 are selected, that is, the directivities of a state that an electric current is supplied to the plate shaped conductor 4 and the plate shaped conductor 5 is grounded in the ground plate 6. Further, the directivity 27 and the directivity 29 show the directivities of a state that an electric current is supplied to the plate shaped conductor 5 and the plate shaped conductor 4 is grounded in the ground plate 6.

[0060]

As apparent from Fig. 6, when the plate shaped conductor 4 is turned on, a gain in the direction of Y is high. When the plate shaped conductor 5 is turned on, the gain in the direction of -Y is high. This tendency is the same as the tendency shown in Fig. 2. However, an amount of variation of a maximum gain in Fig. 6 is apparently higher than that of Fig. 2. This arises because of a reason why the plate shaped conductor that is not turned on is grounded in the ground plate 6 so that these members operate as a reflecting element. As described above, a directional diversity effect obtained by the structure shown in Fig. 5 is higher than that obtained by the

structure shown in Fig. 1.

[0061]

The structures of the high frequency switch 24 and the high frequency switch 25 are not limited to the structure shown in this embodiment. Any of structures that can switch whether the plate shaped conductor is turned on or grounded in the ground plate may obtain the same effects.

[0062]

Third Embodiment

Fig. 7 is a schematic structural diagram of a portable radio device according to a third embodiment of the present invention. The portable radio device in this embodiment is also a portable radio device having a foldable or collapsible structure. In Fig. 7, an opened state (refer this state to as an opening state, hereinafter) is shown. In Fig. 7, the duplicated portions of Fig. 1 are designated by the same reference numerals. Herein, the detailed description is omitted.

[0063]

Comparing to the portable radio device shown in Fig. 1, the portable radio device shown in Fig. 7 further includes a helical element 30 which is inserted between a plate shaped conductor 5 and a high frequency switch 31.

In Fig. 7, the helical element 30 is formed by

winding a conductor in a coil shape. The electric length thereof is preferably set to substantially half-wavelength in an operating frequency (for instance, 900 MHz). In this case, the helical element 30 is inserted between the plate shaped conductor 5 and the high frequency switch 31, so that a phase for exciting the plate shaped conductor 5 is inverted.

[0064]

Figs. 8 and 9 are side views of the portable radio device shown in Fig. 7 and show states that an upper case 1 and a lower case 2 are closed (refer this state to as a closing state, hereinafter). Fig. 8 shows a state that a terminal A1 side of the high frequency switch 31 shown in Fig. 7 is selected, that is, a plate shaped conductor 4 is selected. Fig. 9 shows a state that a terminal A2 side of the high frequency switch 31 shown in Fig. 7 is selected, that is, the plate shaped conductor 5 is selected.

[0065]

In the state shown in Fig. 8, the phases of antenna currents distributed in the plate shaped conductor 4 and a ground plate 6 are shown by arrow marks. Accordingly, the antenna currents on the plate shaped conductor 4 and the ground plate 6 are respectively cancelled to each other so that a radiation resistance is extremely lowered. Thus, the radiation efficiency of an antenna is lowered to

increase a loss in non-matching of impedance. As a result, an antenna gain of this state is decreased to reduce a bandwidth.

[0066]

As compared therewith, in the state that the terminal A2 side of the high frequency switch 31 as shown in Fig. 9 is selected, that is, in the state that the helical element 30 and the plate shaped conductor 5 are selected, the phases of antenna currents distributed on the plate shaped conductor 5 and the ground plate 6 correspond to each other.

[0067]

Fig. 10 shows the directivities of Eθ components of the state shown in Fig. 9 on an XY plane and an XZ plane. As apparent from Fig.10A and Fig. 10, the Eθ components substantially have no directivities on a horizontal plane (XY plane) and have 8-shaped directivities on the XZ plane. Under this state, a high antenna gain and a wide bandwidth can be assured.

[0068]

In such a way, when the portable radio device is in the opening state, the high frequency switch 31 is switched to the terminal A1 side. When the portable radio device is in the closing state, the high frequency switch

is switched to the terminal A2 side. Thus, an antenna performance can be obtained in both the states.

[0069]

The helical elements 30 whose electric length has substantially half-wavelength may have the same effects. For instance, a meander pattern printed on a printed circuit board or an insulator may be employed. Further, the helical element 30 may be formed with a meander conductor as a part of the plate shaped conductor 5.

[0070]

Fourth Embodiment

Fig. 11 is a schematic structural diagram of a portable radio device in a fourth embodiment of the present invention. The portable radio device of this embodiment is also a portable radio device having a foldable or collapsible structure. Fig. 11 shows an opened state (refer this state to as an opening state, hereinafter). In Fig. 11, duplicated portions to those of Fig. 7 are designated by the same reference numerals of Fig. 7.

[0071]

Comparing to the portable radio device shown in Fig. 7, in the portable radio device shown in Fig. 11, a helical element 32 is inserted between a feeding point 34 of a plate shaped conductor 4 and a high frequency switch

33 and a feeding point 11 of a plate shaped conductor 5 is connected to the high frequency switch 33.

In Fig. 11, the helical element 32 has the same electric characteristics as those of a helical element 30. A high frequency switch 31 and the high frequency switch 33 are selected by a high frequency switch 36 to supply electric current to a feeding portion 15.

[0072]

In the above-described structure, under a state that a terminal A1 side of the high frequency switch 31 and a terminal B1 side of the high frequency switch 33 are selected, the plate shaped conductor 4 or the plate shaped conductor 5 and a ground plate 6 operate as a dipole antenna having the same structure shown in Fig. 1. In the opening state, this state is desirably selected. In that case, a high antenna gain can be obtained. Then, at this time, the plate shaped conductor 4 or the plate shaped conductor 5 is selected by the high frequency switch 36 so that a directional diversity effect is obtained.

[0073]

Then, under a closing state, a terminal A2 side of the high frequency switch 31 and a B2 side of the high frequency switch 33 are desirably selected. In this state, an antenna operation similar to that of the structure shown in Fig. 9 is achieved so that the high antenna gain

can be obtained under the closing state. At this time, the plate shaped conductor 4 or the plate shaped conductor 5 is selected by the high frequency switch 36 so that a directional diversity effect under the closing state can be obtained.

[0074]

Fifth Embodiment

Fig. 12 is a schematic structural diagram of a portable radio device in a fifth embodiment of the present invention. The portable radio device of this embodiment is also a portable radio device having a foldable or collapsible structure. Fig. 12 shows an opened state (refer this state to as an opening state, hereinafter). In Fig. 12, duplicated portions to those of Fig. 7 are designated by the same reference numerals of Fig. 7. Herein, the detailed description is omitted.

[0075]

Comparing to the portable radio device shown in Fig. 7, the portable radio device shown in Fig. 12 further includes a matching circuit 37 and a matching circuit 38. When a plate shaped conductor 4 is selected in the opening state, or when a plate shaped conductor 5 is selected in a closing state, a suitable impedance matching is performed for both the cases.

[0076]

Further, a control portion 39, a magnet switch 40 and a permanent magnet 41 are added to detect the opening state or the closing state of the portable radio device and switch a high frequency switch 31 in accordance therewith.

[0077]

In Fig. 12, the matching circuit 37 and the matching circuit 38 are formed with, for instance, concentrated constant elements such as inductance and condensers. The matching circuit 37 operates so that the impedance of a dipole antenna formed by the plate shaped conductor 4 in the opening state and a ground plate 6 is matched with the impedance (ordinarily, 50 Ω) of a feeding portion 15. Further, the matching circuit 38 operates so that the impedance of an antenna formed by the plate shaped conductor 5 in the closing state, a helical element 30 and the ground plate 6 is matched with the impedance of the feeding portion 15.

[0078]

As described above, the suitable matching circuits are provided respectively for the plate shaped conductors or the opening and closing states. Thus, an antenna performance for each of the states is more improved.

[0079]

Then, for instance, in the closing state, since the magnet switch 40 comes near to the permanent magnet 41, the magnet switch 40 is turned ON. The control portion 39 detects this state and operates to switch the high frequency switch 31 to a terminal B side. On the other hand, in the opening state, the magnet switch 40 is turned OFF to switch the high frequency switch 31 to a terminal A side.

[0080]

In such a way, suitable antenna states are selected in accordance with the detection results of the opening and closing states, so that a high antenna gain can be obtained for both the states.

[0081]

The matching circuit is not limited to a circuit composed of the concentrated constant elements and may be formed by, for instance, a plane circuit disposed on a printed circuit board. Further, means for detecting the opening and closing states is not limited to the magnet switch and the permanent magnet. For instance, means for detecting an operation of a mechanism of a hinge portion may be employed, or means interlocking with an operating state such as a speaking mode or a waiting mode of the portable radio device may be employed.

[0082]

Sixth Embodiment

Fig. 13 is a schematic structural diagram of a portable radio device in a sixth embodiment of the present invention. The portable radio device of this embodiment is also a portable radio device having a foldable or collapsible structure. Fig. 13 shows an opened state (refer this state to as an opening state, hereinafter). In Fig. 13, duplicated portions to those of Fig. 7 or Fig. 12 are designated by the same reference numerals of Fig. 7 or Fig. 12. Herein, the detailed description is omitted.

[0083]

In the portable radio device shown in Fig. 13, the ground plate 6 in the portable radio device shown in Fig. 7 is formed with a ground pattern 43 on a printed circuit board 42. A radio circuit portion 44 and a level deciding portion 45 mounted on the printed circuit board 42 are added.

[0084]

In Fig. 13, as the printed circuit board 42, for instance, a glass epoxy base having the thickness of about 1 mm is used. The ground pattern 43 is formed with a silver foil pattern printed on the surface or the inner layer of the printed circuit board 42. The ground pattern 43 functions as an antenna in the same manner as that of the ground plate 6 in Fig. 7. Such a structure is

provided so that the ground plate operating as the antenna does not need to be overlaid on the printed circuit board 42 as an originally necessary component. Thus, the decrease of thickness of a lower case 2 of the portable radio device can be realized.

[0085]

The radio circuit portion 44 is composed of a transmitting circuit and a receiving circuit and covered with electromagnetic shielding means such as a shield case. A signal selected by a high frequency switch 31 is transmitted to the radio circuit portion 44 and the ground of the radio circuit portion 44 is grounded in the ground pattern 43. In accordance with such a structure, to an antenna formed by plate shaped conductors 4 and 5 and the ground pattern 43, electric current is fed by the radio circuit portion 44.

[0086]

The level deciding portion 45 includes a function for deciding whether a reception level obtained in the receiving circuit that forms the radio circuit portion 44 is high or low and a function for switching the high frequency switch 31 in accordance therewith. Specifically, the reception levels are respectively determined when the high frequency switch 31 is switched to a terminal A side or a terminal B side and operates to select the terminal

side of a higher reception level. For instance, when the portable radio device of this embodiment is applied to a time division multiplex connection (TDMA) system, a series of operations as described above are continuously carried out at a suitable timing. Accordingly, a high antenna gain can be always ensured.

[0087]

[Advantage of the Invention]

As mentioned above, in a portable radio device of the invention, a dipole antenna is made of an upper antenna element built in upper casing and a lower antenna element built in a lower casing, and there is an advantage capable of comparatively obtaining a high antenna gain when the portable radio device is held by a hand.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a schematic structural diagram of a portable radio device in a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a diagram showing the directivity of an antenna of the portable radio device according to the first embodiment.

[Fig. 3] Fig. 3 is an explanatory view for explaining using states of the portable radio device according to the first embodiment.

[Fig. 4] Fig. 4 is a diagram showing the directivity

of the antenna under a state in which the portable radio device according to the first embodiment is inclined by 60 degrees.

[Fig. 5] Fig. 5 is a schematic structural diagram of a portable radio device in a second embodiment of the present invention.

[Fig. 6] Fig. 6 is a diagram showing the directivity of an antenna of the portable radio device according to the second embodiment.

[Fig. 7] Fig. 7 is a schematic structural diagram of a portable radio device in a third embodiment of the present invention.

[Fig. 8] Fig. 8 is an explanatory view showing the operation of a closing state (first) of the portable radio device according to the third embodiment.

[Fig. 9] Fig. 9 is an explanatory view showing the operation of a closing state (second) of the portable radio device according to the third embodiment.

[Fig. 10] Fig. 10 is a diagram showing the directivity of an antenna of the portable radio device according to the third embodiment.

[Fig. 11] Fig. 11 is a schematic structural diagram of a portable radio device in a fourth embodiment of the present invention.

[Fig. 12] Fig. 12 is a schematic structural diagram

of a portable radio device in a fifth embodiment of the present invention.

[Fig. 13] Fig. 13 is a schematic structural diagram of a portable radio device in a sixth embodiment of the present invention.

[Description of Reference Numerals and Signs]

1: UPPER CASE (UPPER CASING)

2: LOWER CASE (LOWER CASING)

3: HINGE PORTION

4: PLATE SHAPED CONDUCTOR (UPPER ANTENNA ELEMENT)

5: PLATE SHAPED CONDUCTOR (UPPER ANTENNA ELEMENT)

6: GROUND PLATE (LOWER ANTENNA ELEMENT)

7: SPEAKER

8: OPERATING KEY

9: MICROPHONE

10, 11, 34, 35: FEEDING POINT

12, 13: FEEDER

14, 24, 25, 31, 33, 36: HIGH FREQUENCY SWITCH

15: FEEDING PORTION

30, 32: HELICAL ELEMENT

37, 38: MATCHING CIRCUIT

39: CONTROLLER

40: MAGNET SWITCH

41: PERMANENT MAGNET

42: PRINTED CIRCUIT

43: GROUND PATTERN (LOWER ANTENNA ELEMENT)

44: RADIO CIRCUIT PORTION

45: LEVEL DECIDING PORTION

[Designation of Document] Abstract

[Abstract]

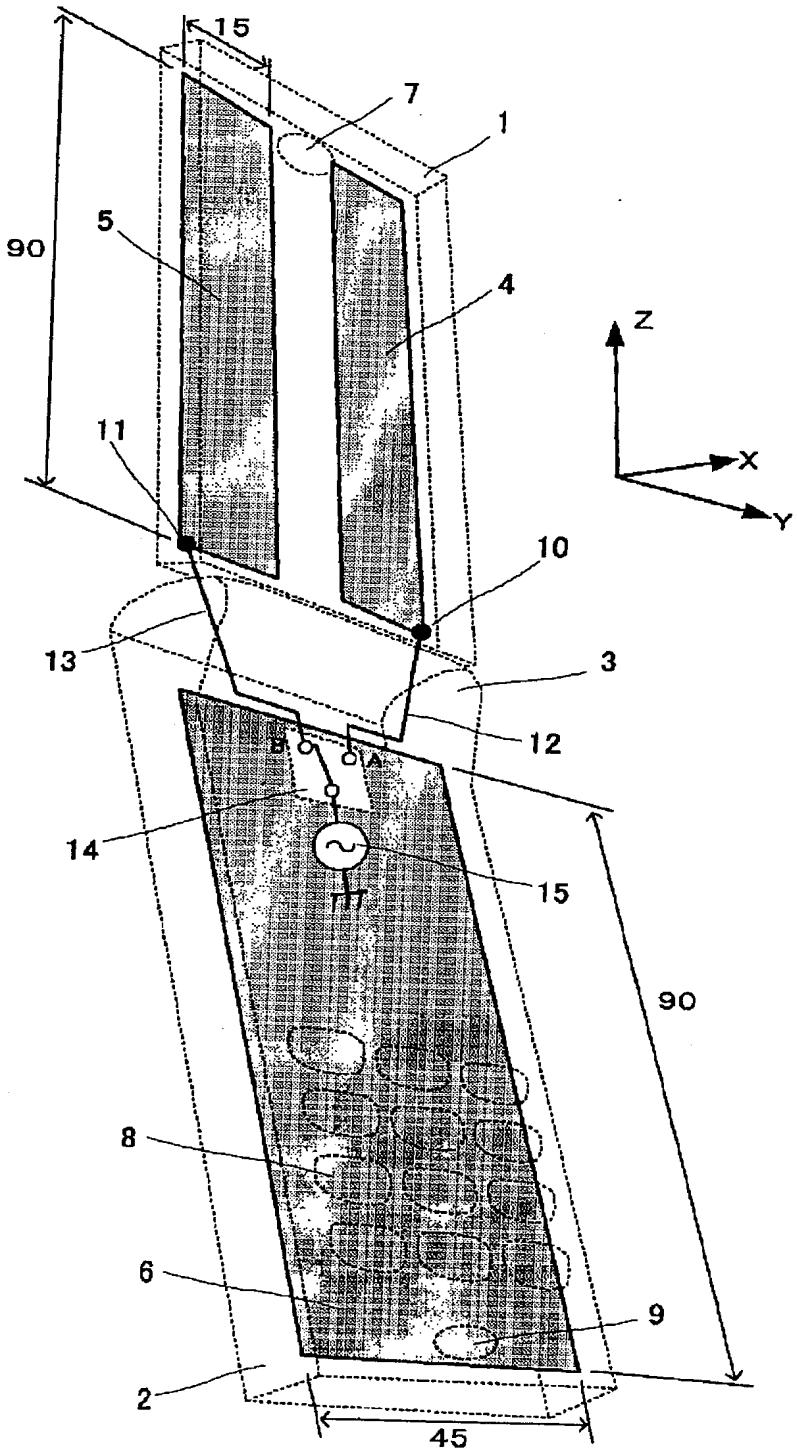
[Task] To provide foldable cellular phone including a contained antenna which has a high gain under various using states and is capable of decreasing in thickness.

[Means for Resolution] An upper case 1 is connected to a lower case 2 in a hinge portion 3 so as to freely rotate. A plate shaped conductor 4 and a plate shaped conductor 5 are disposed along the surface of the case in the upper case 1. A ground plate 6 is formed in a ground pattern of a printed circuit board disposed in the lower case 2. The plate shaped conductor 4 and the plate shaped conductor 5 are selected by a high frequency switch 14 and connected to one end of a feeding portion 15. The other end of the feeding portion 15 is connected to the ground plate 6 to form a dipole antenna.

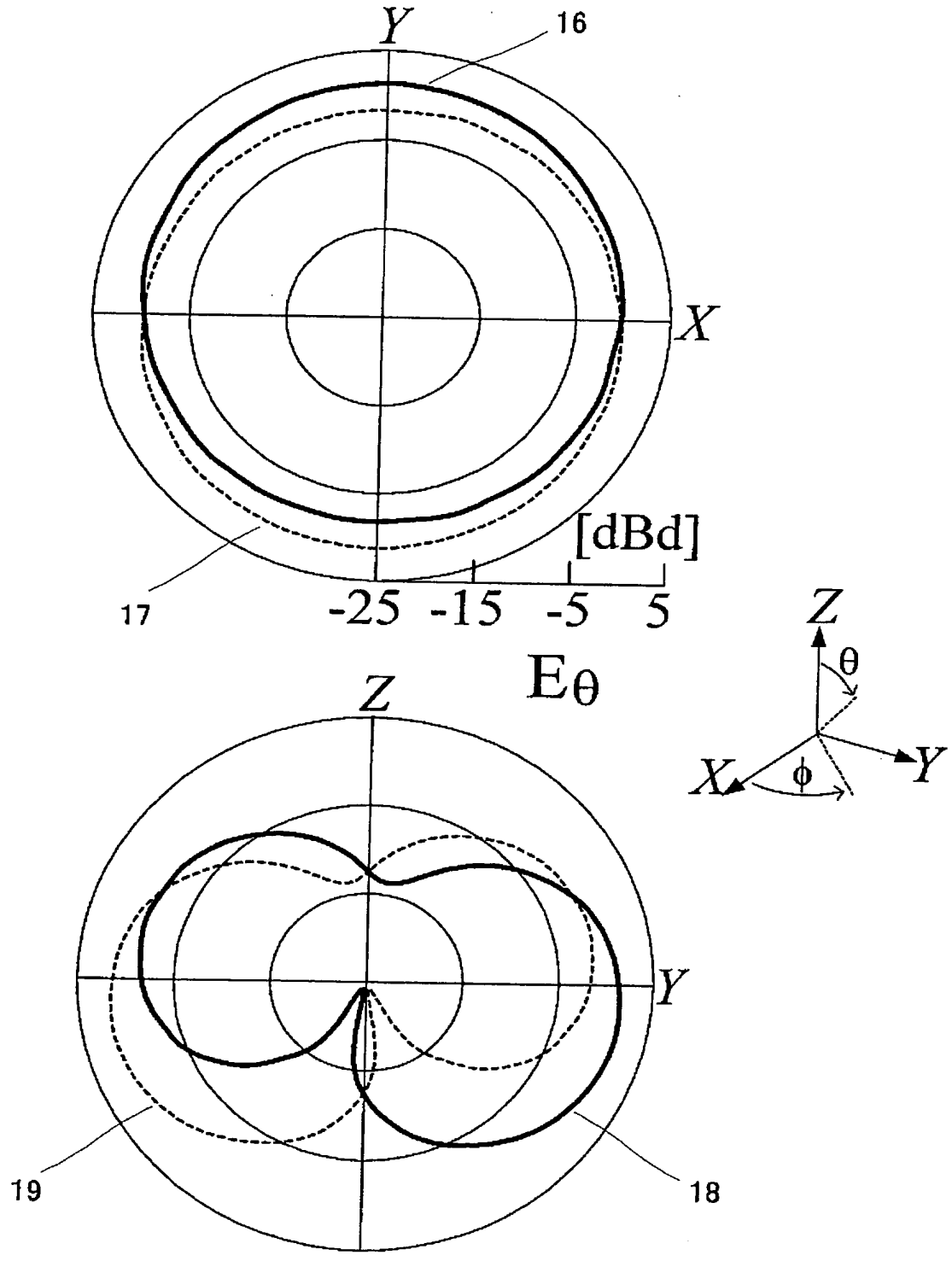
[Selected Drawing] Fig. 1

【書類名】　図面

【~~図1~~】 Fig. 1

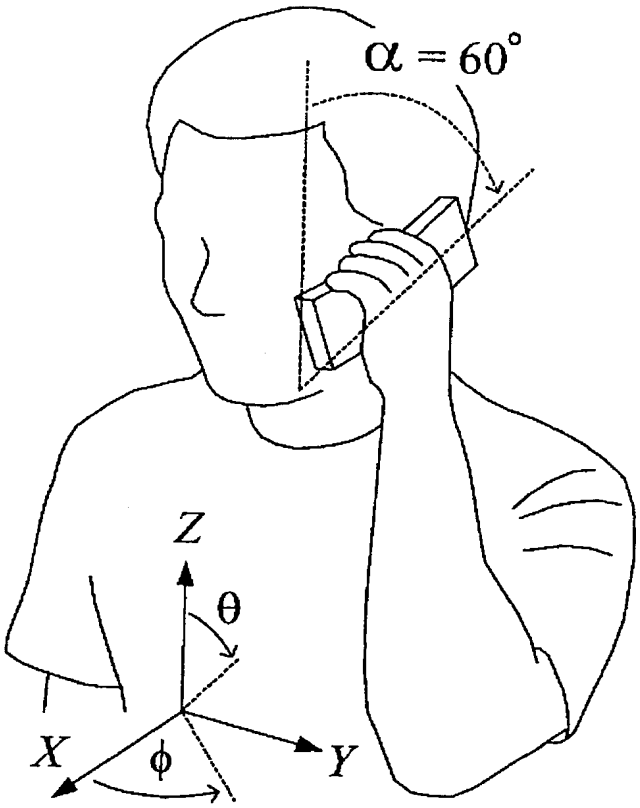


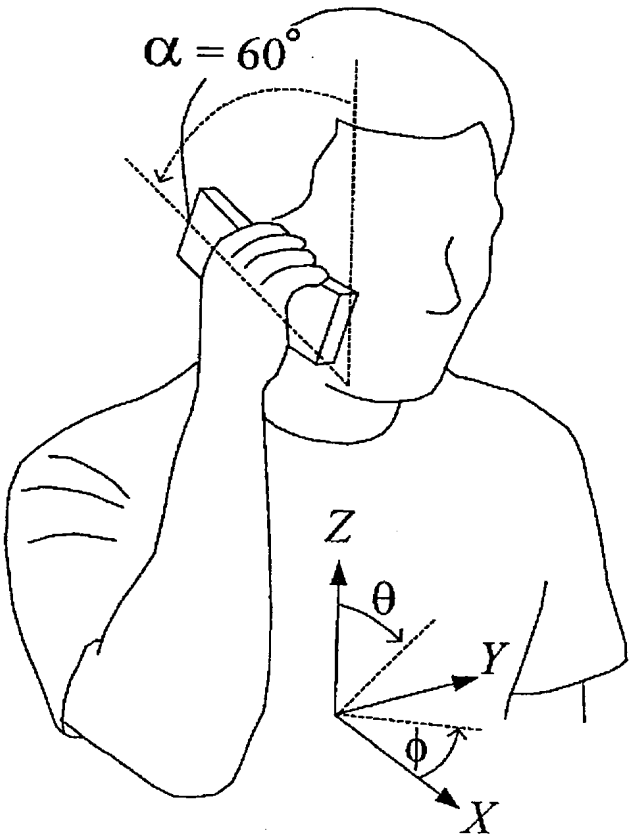
【~~図2~~】 Fig.2



【図３】

Fig.3

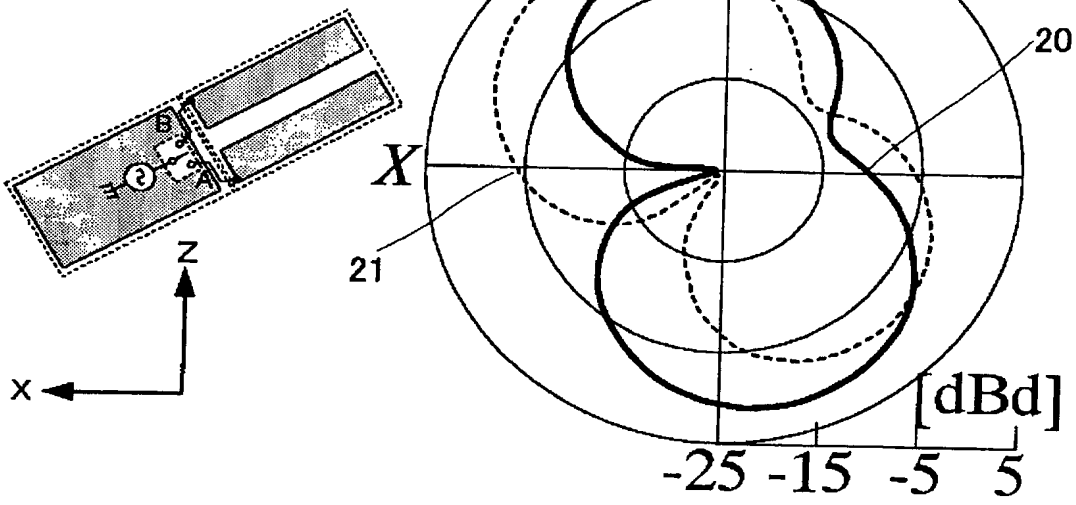




【~~図4~~】 Fig. 4

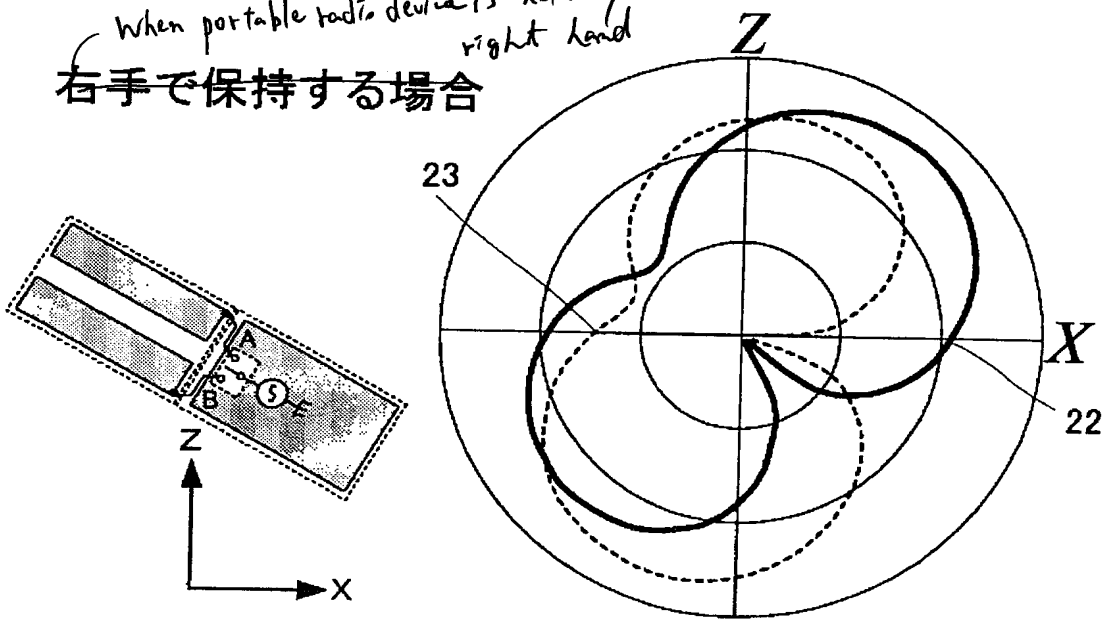
When portable radio device is held by left hand

左手で保持する場合



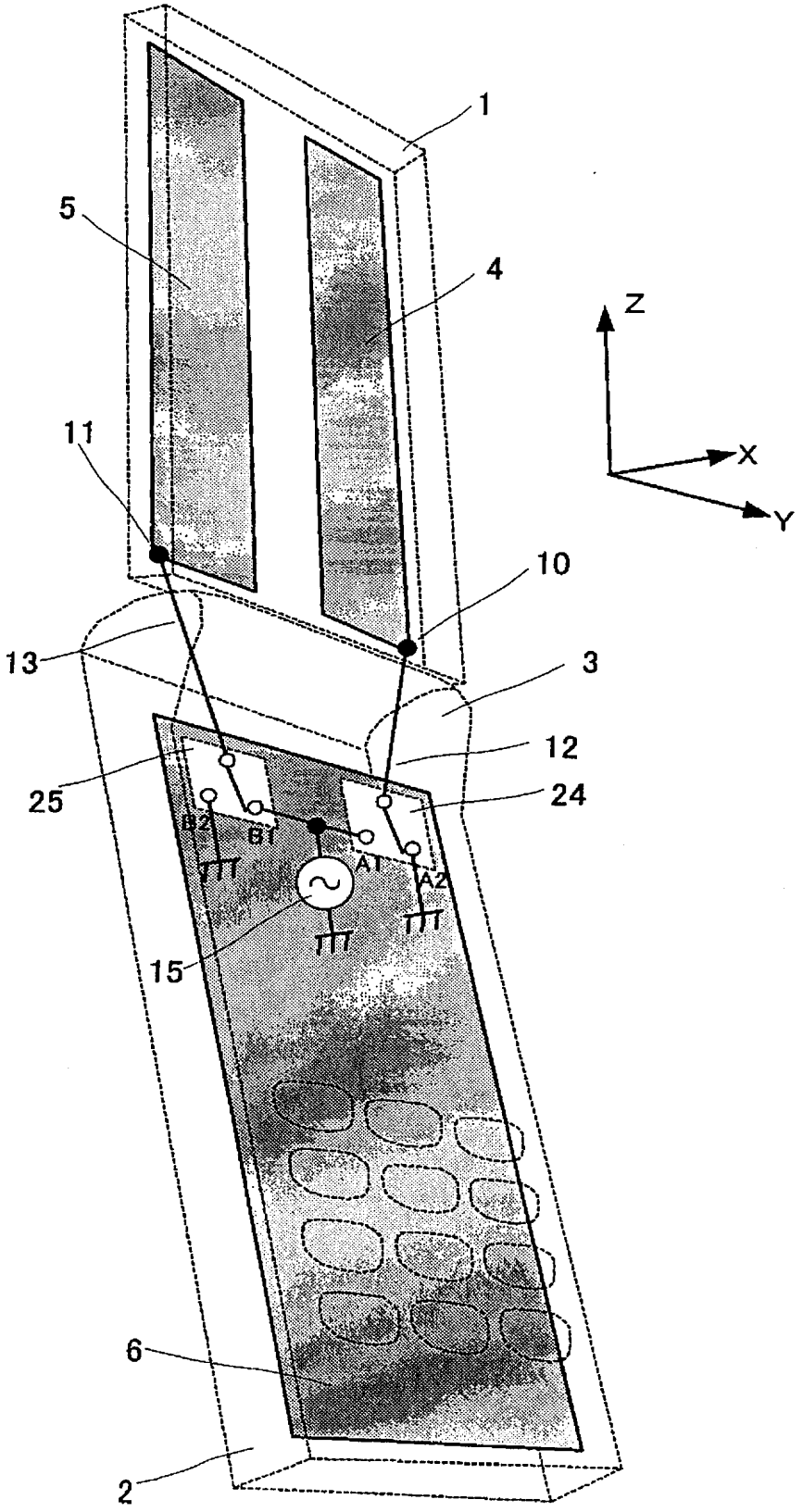
When portable radio device is held by right hand

~~右手で保持する場合~~

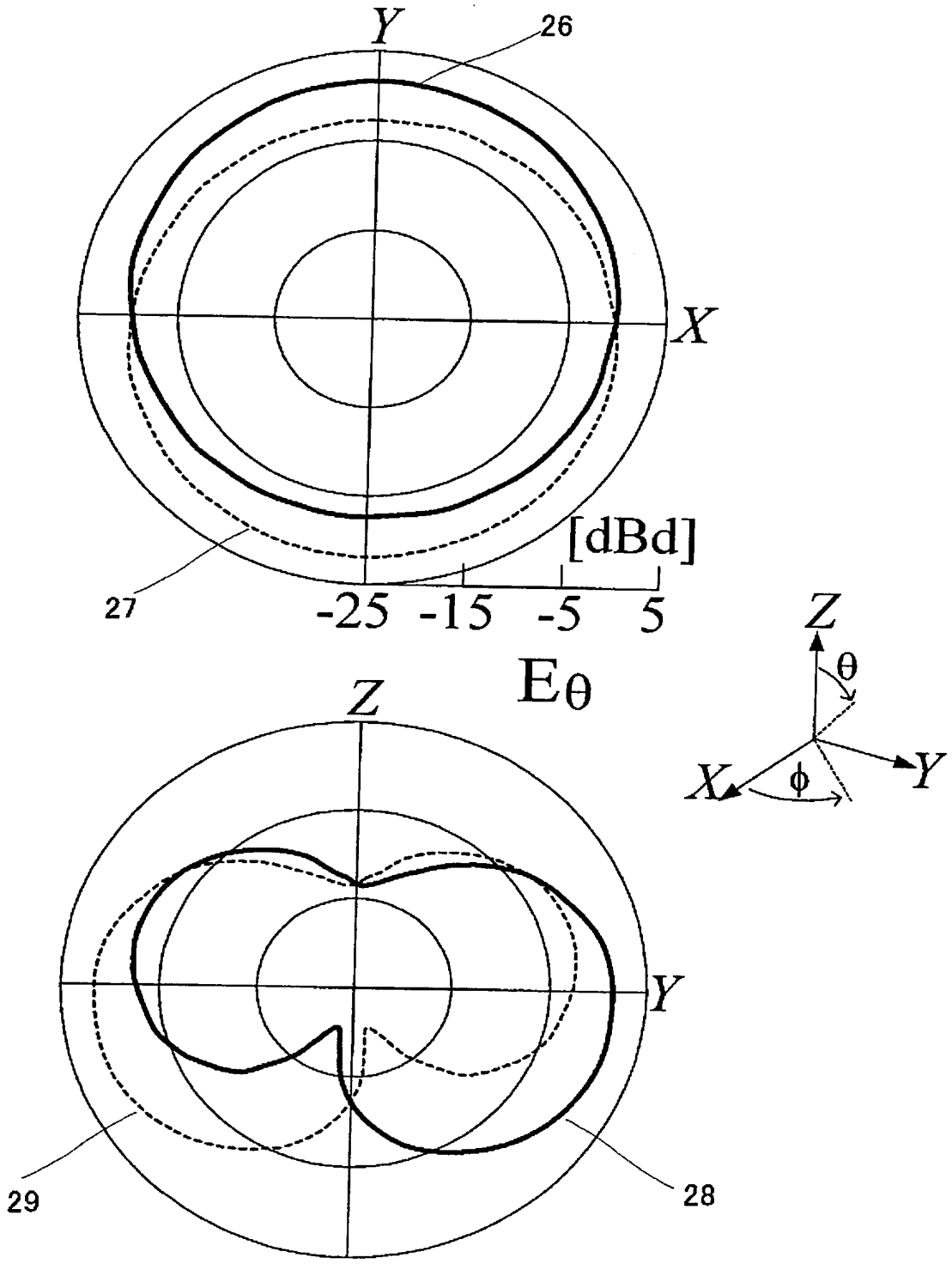


【図５】

Fig.5

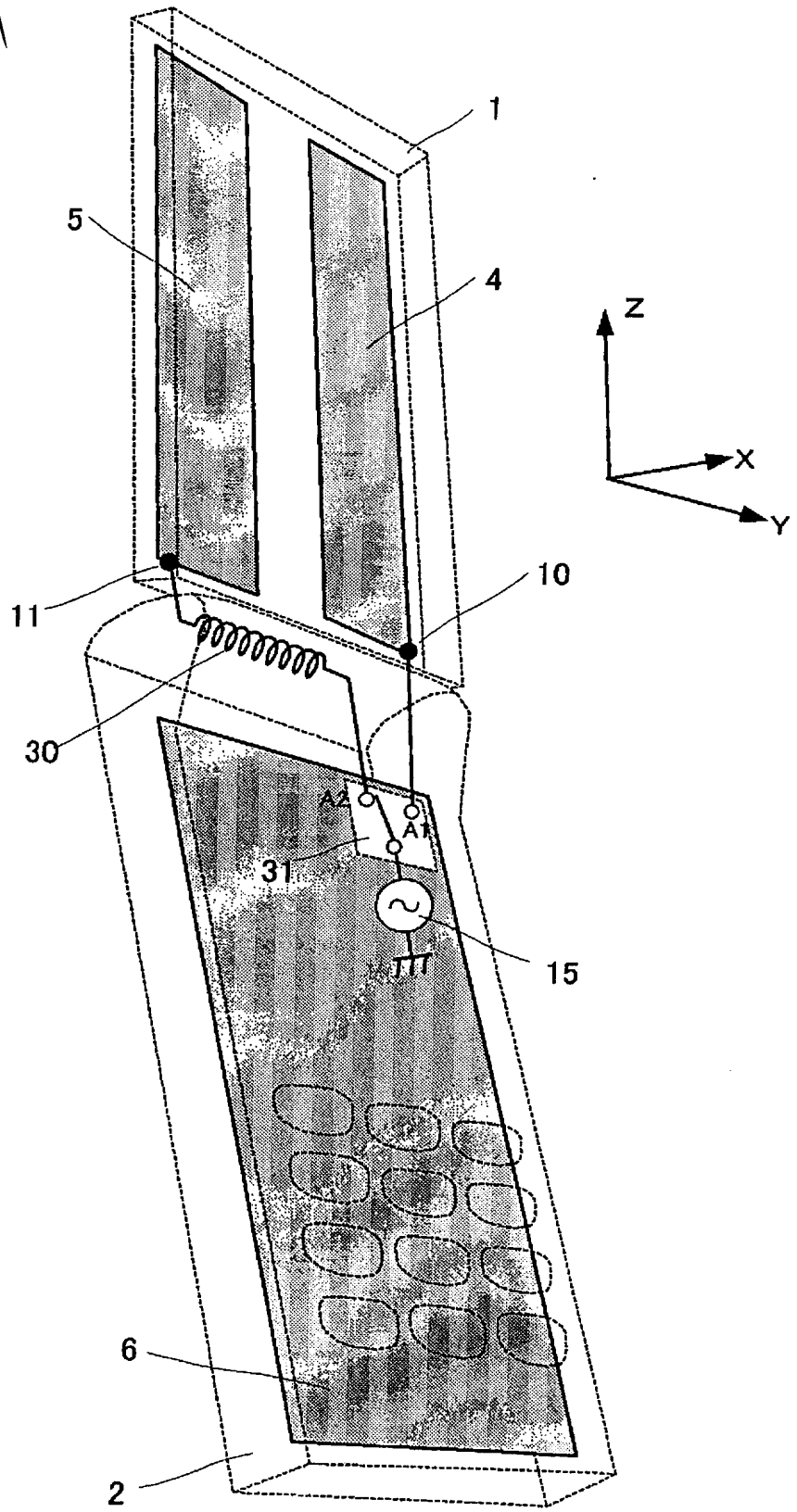


【図６】
Fig. 6



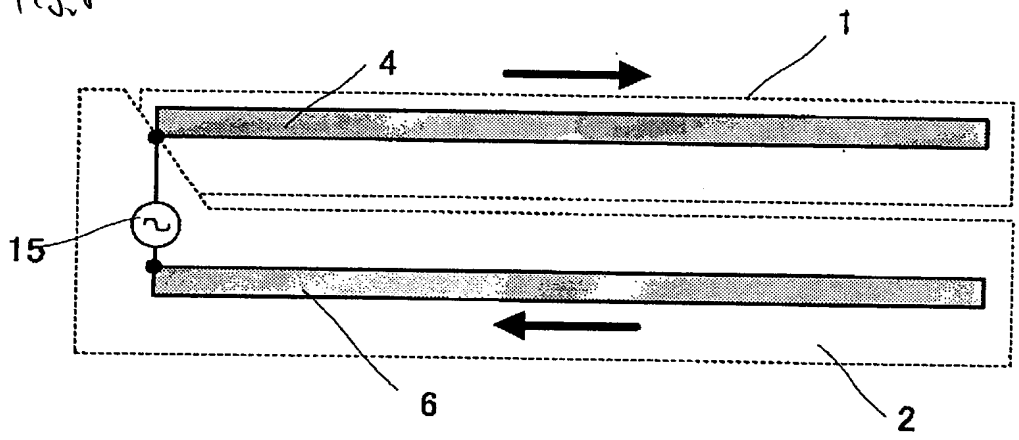
【図７】

Fig.7



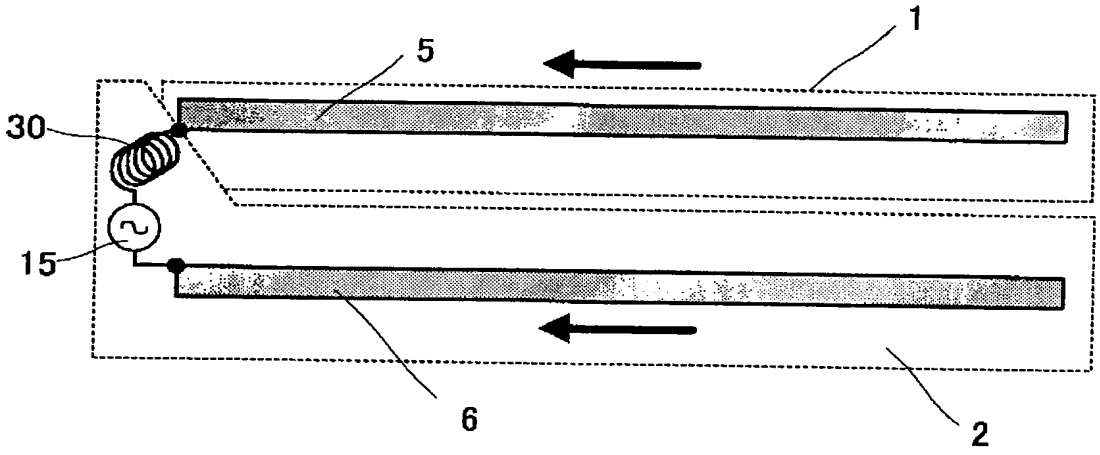
【図８】

Fig.8



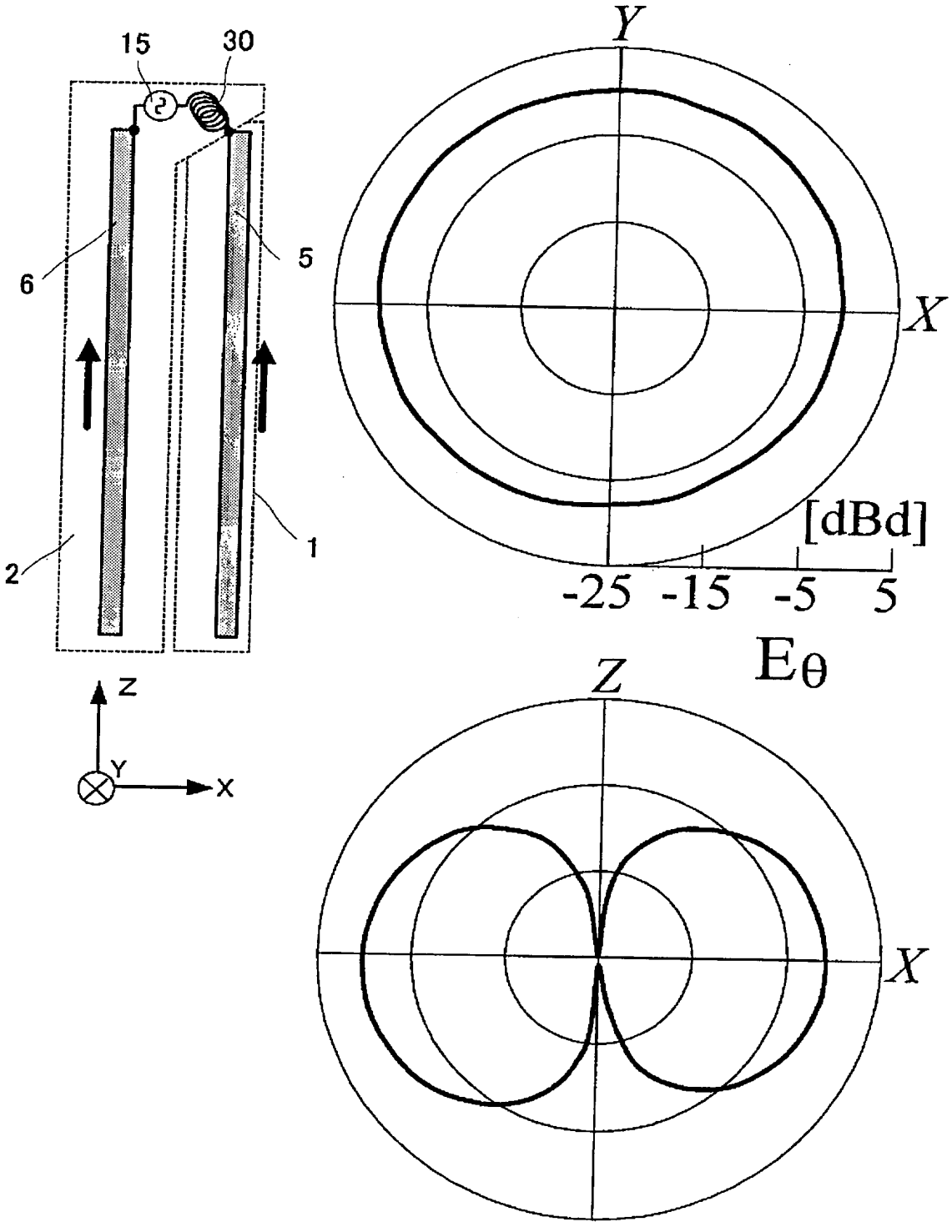
【図９】

Fig.9



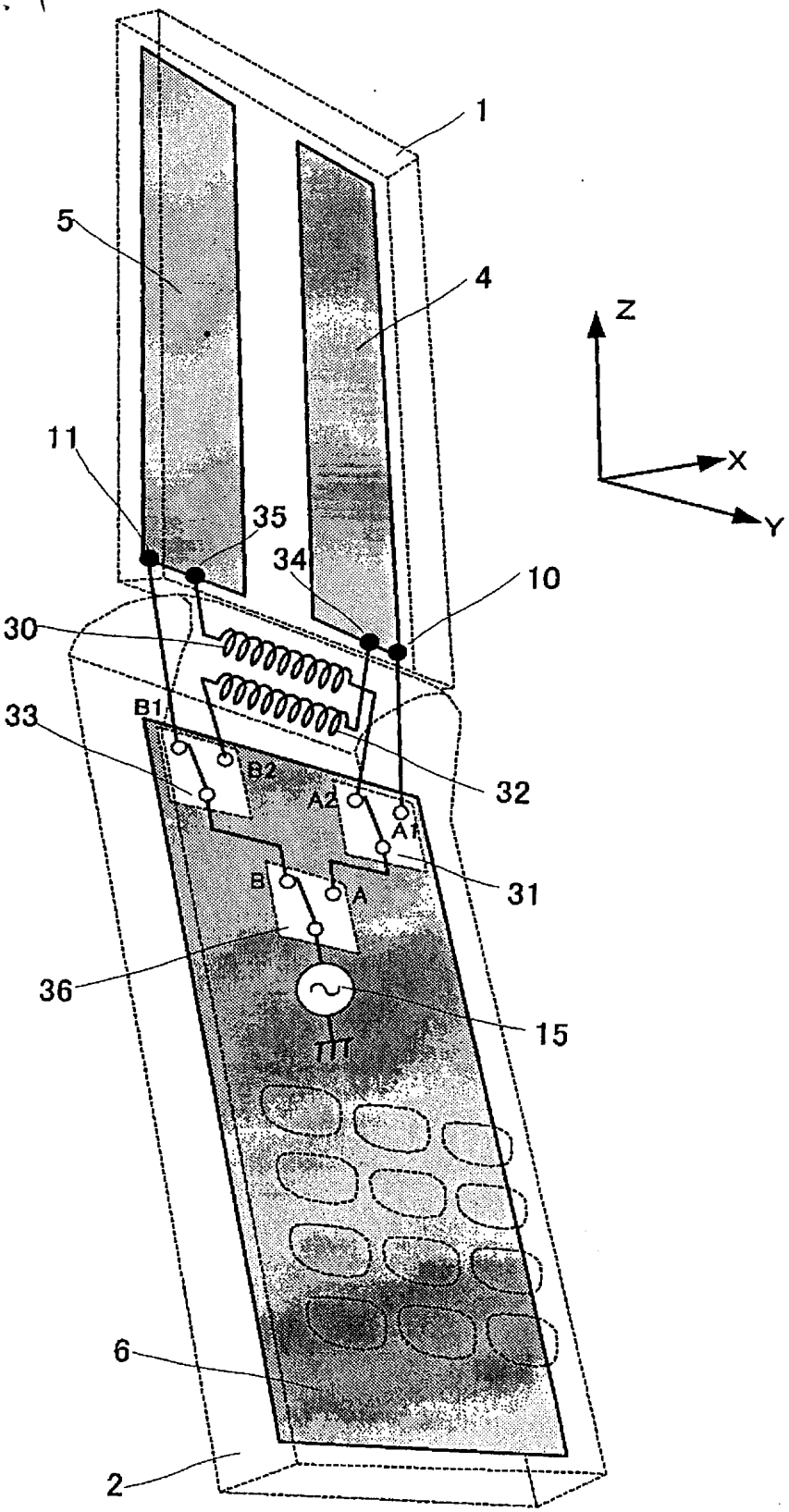
【図１０】

Fig.10



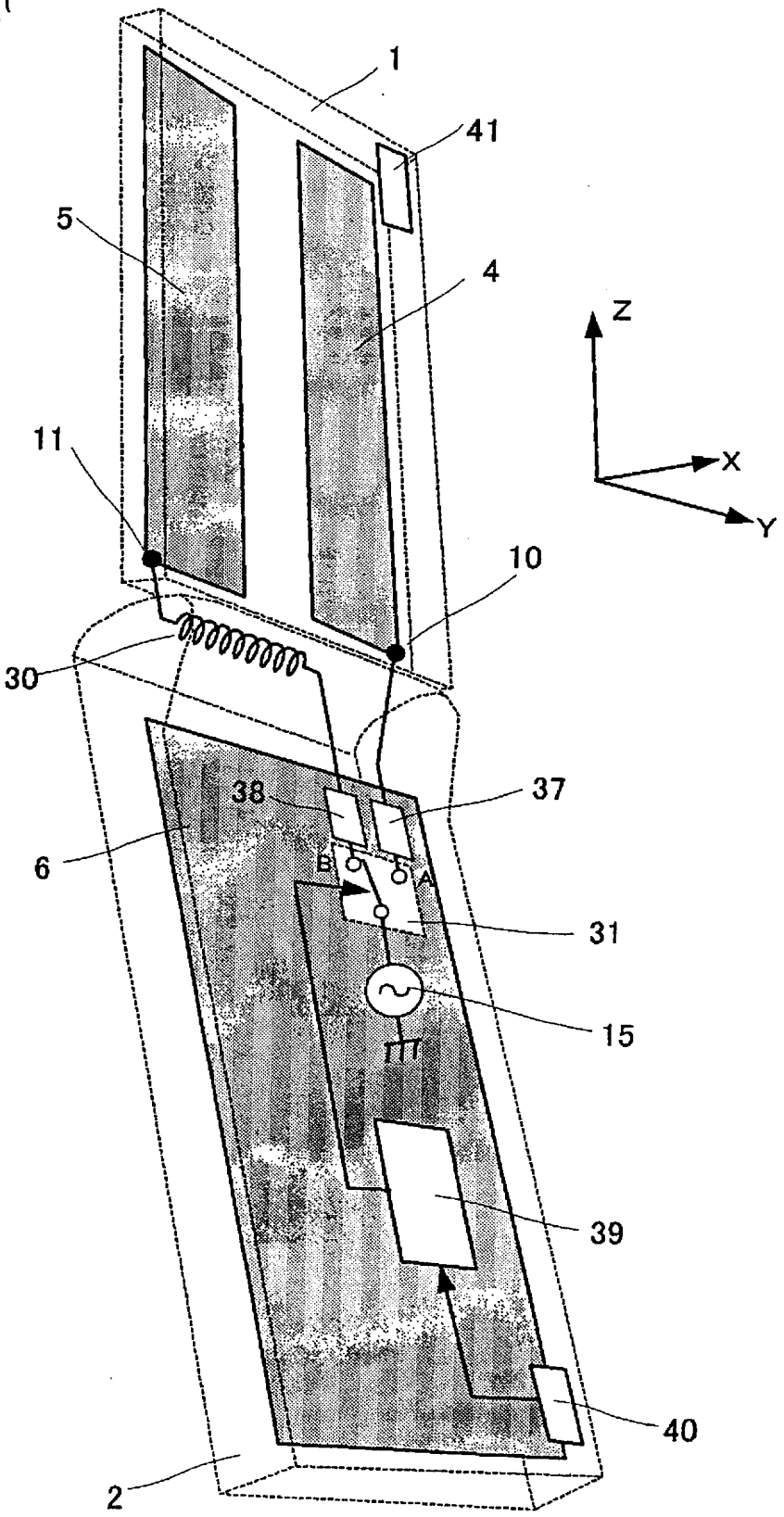
【図１１】

Fig. 11



【図１２】

Fig.12



【図１３】

Fig. 13